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-	195	(34/96).CCLS.	USPAT; US-PGPUB	2003/10/14 13:54
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United States Patent [19]
Carlson

[11] **4,316,077**
[45] **Feb. 16, 1982**

[54] **ELASTIC HAIR DRYER HAVING SELECTIVELY VARIABLE AIR OUTPUT TEMPERATURE**

[75] Inventor: **Richard H. Carlson**, Cumberland, R.I.

[73] Assignee: **Texas Instruments Incorporated**, Dallas, Tex.

[21] Appl. No.: **645,861**

[22] Filed: **Dec. 31, 1975**

[51] Int. Cl.³ **A45D 20/10**; F24H 3/04; H05B 3/12

[52] U.S. Cl. **219/370**; 34/97; 165/96; 165/103; 165/122; 219/367; 219/374; 219/375; 219/381; 219/505

[58] Field of Search .... 219/366-370, 219/374-376, 381-382, 504, 505; 165/86, 103, 96, 122; 34/96-101, 243 R

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,626,400	4/1927	Frank	219/375 UX
1,707,554	4/1929	Hendry	34/99 X
2,147,283	2/1939	Covell	165/96 X
3,305,665	2/1967	Laing	165/122 X
3,674,980	7/1972	Cox	165/103 X
3,927,300	12/1975	Wada	219/374

FOREIGN PATENT DOCUMENTS

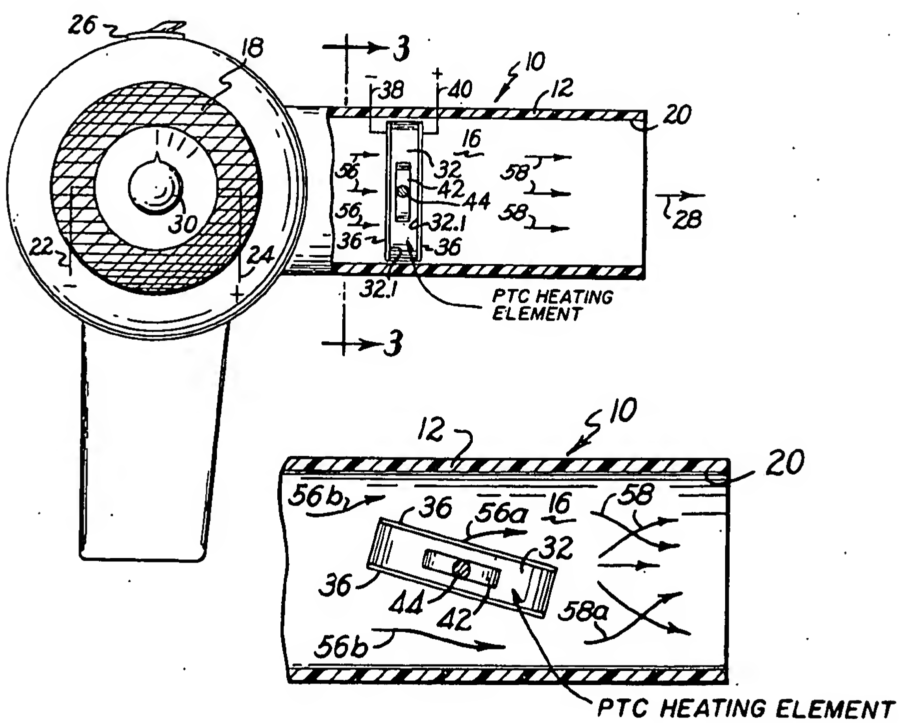
313229	5/1956	Switzerland	219/381

Primary Examiner—A. Bartis
Attorney, Agent, or Firm—James P. McAndrews; John A. Haug; Melvin Sharp

[57] **ABSTRACT**

A hair dryer for use in personal beauty care incorporates a blower for moving a stream of air through a dryer housing onto the hair. A self-regulating, disc-shaped, electrical resistance heater body formed of a ceramic material of positive temperature coefficient of resistivity (PTC) and having a multiplicity of air flow passages extending between the opposite faces thereof is arranged the housing for heating the air stream. The heater body is mounted for rotational movement between a first position wherein the passages are parallel to the air flow direction so that substantially all of the air stream is directed through the passages and a second position wherein the passages are oblique to the air flow direction so that a substantial part of the air stream passes around the heater body without passing through the passages, whereby the temperature of the heated air directed onto the hair can be selectively varied by rotating the heater body to adjust the proportion of the air stream which is allowed to flow through the heater body passages. The heater body may be provided with baffles to maintain the air flow constant while the air temperature is varied by rotation of the heater body.

2 Claims, 9 Drawing Figures



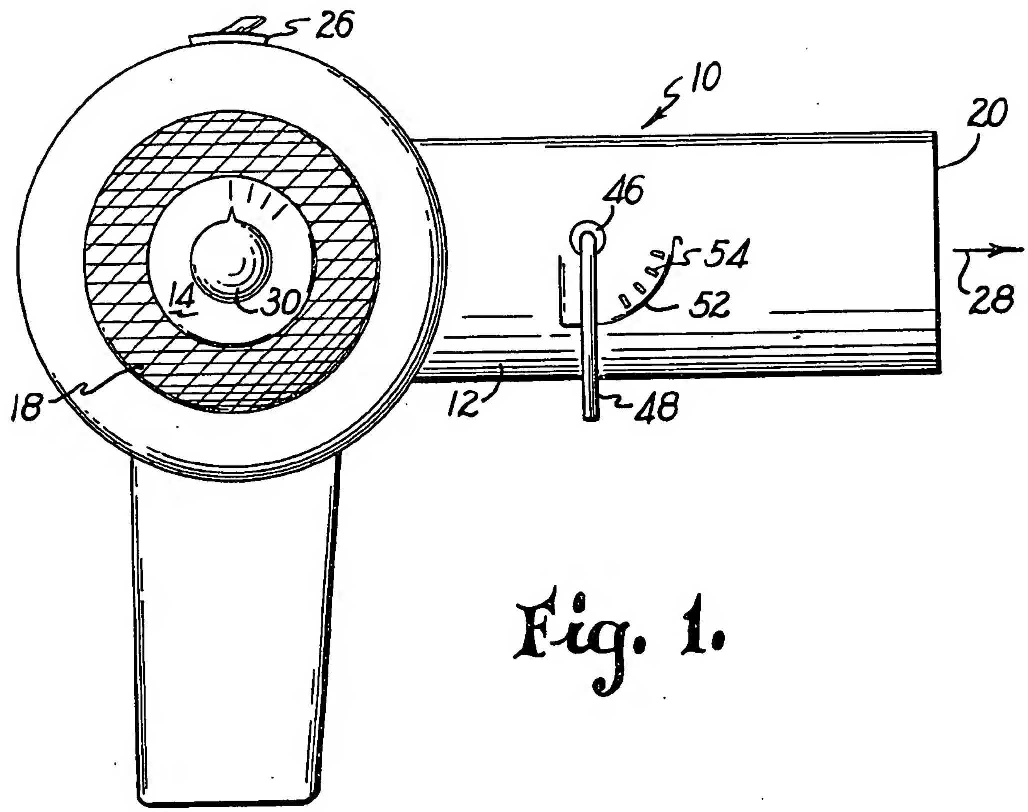

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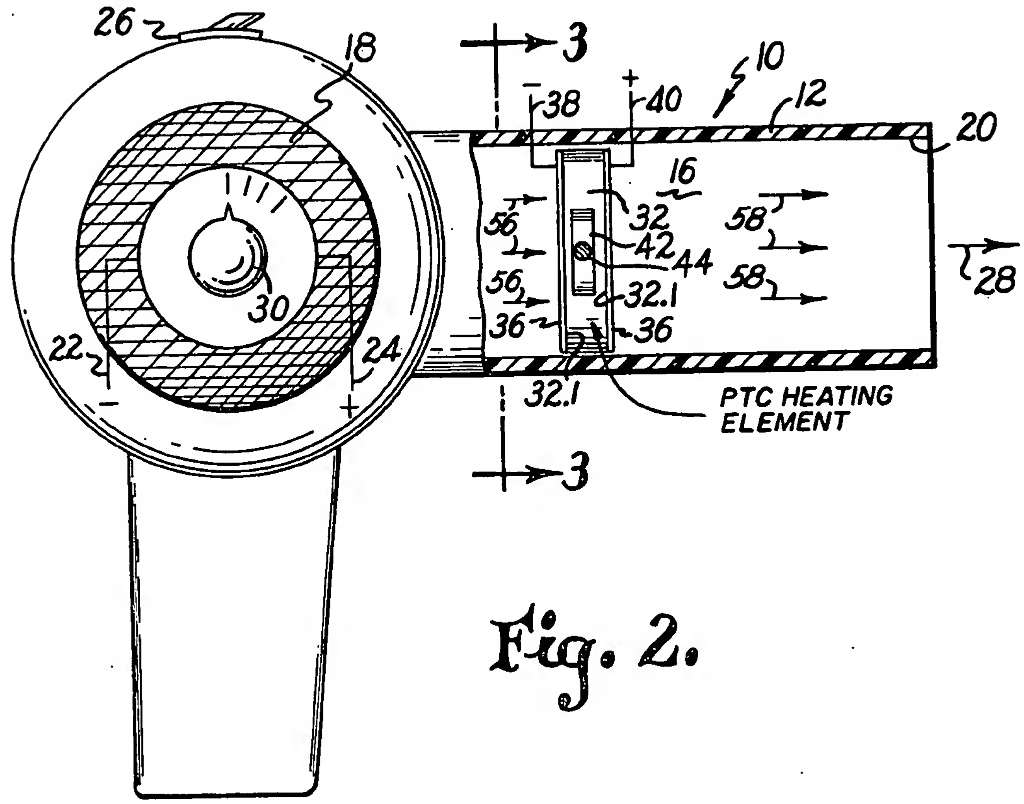
Fig. 1.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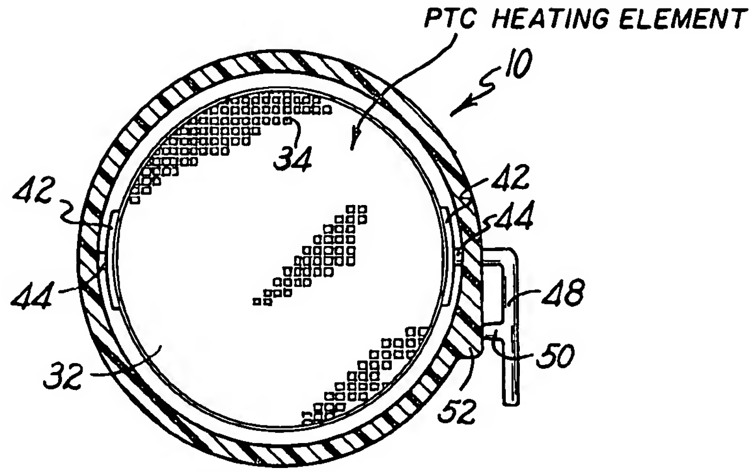
PTC HEATING
ELEMENT
3

Fig. 2.



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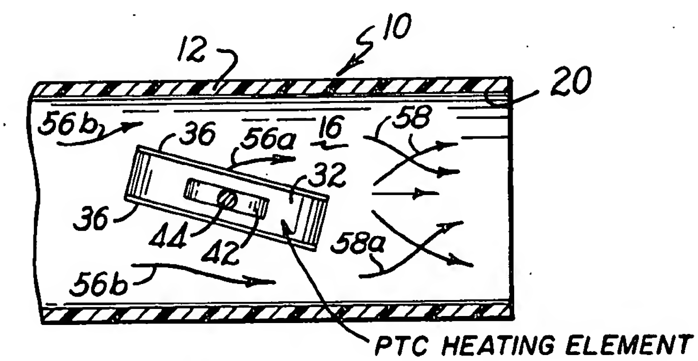

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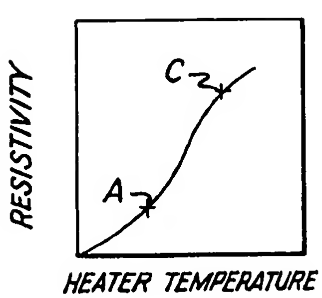


Fig. 5a.

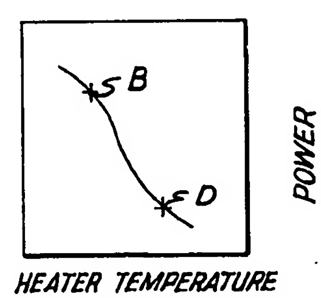


Fig. 5b.

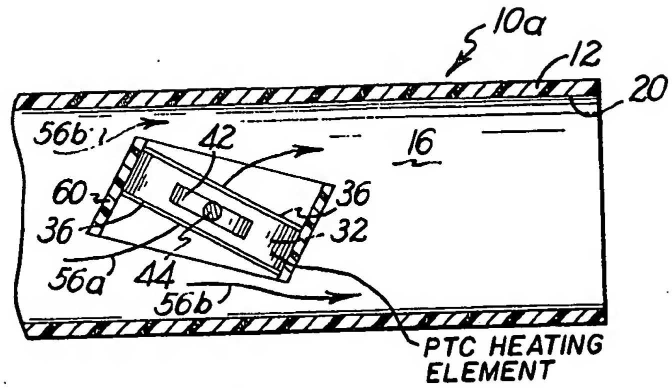


Fig. 6.

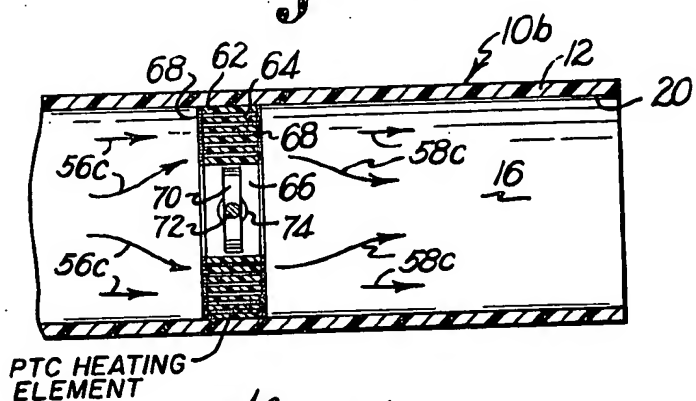


Fig. 7.

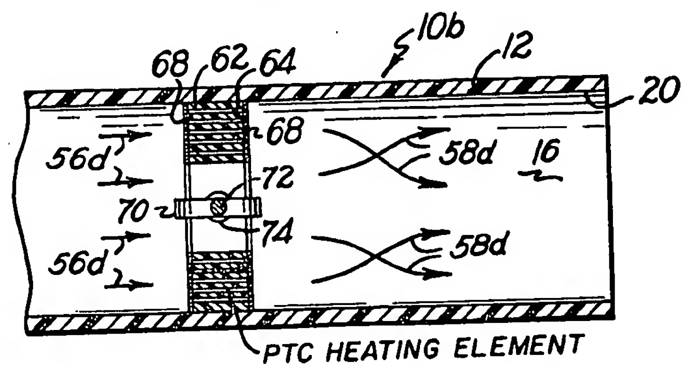


Fig. 8.

ELASTIC HAIR DRYER HAVING SELECTIVELY VARIABLE AIR OUTPUT TEMPERATURE

BACKGROUND OF THE INVENTION

In a conventional hair dryer, a blower moves air through the dryer onto the hair and an electrical resistance heater is commonly positioned within the dryer to heat the air. In the conventional dryer, however, it has been difficult and expensive to provide a sufficiently large volume of air and to provide adequate capacity for heating such a large volume of air while also assuring that the dryer is safe to operate. That is, if the heater of the conventional dryer were provided with the desired large heating capacity, there would be a significant risk that, if the air intake to the dryer were to be inadvertently blocked or if air supply to the dryer were otherwise cut-off, the large heater could be subjected to catastrophic overheating. As a result, conventional hair dryers intended for the lower price segment of the beauty care market have commonly been provided with somewhat limited air volume and heating capacities.

It had been known that a highly efficient fluid heater could be formed from a body of electrical resistance material having a plurality of fluid passages extending through the body, the heater material having a positive temperature coefficient of resistivity and being adapted to display a sharp, anomalous increase in resistivity when self-heated to a selected temperature by directing electrical current through the body. It had also been known that, if utilized in a hair dryer or the like, such an electrical resistance heater would be self-regulating to eliminate the risk of overheating. That is, when such a heater is electrically energized while a stream of air or other fluid is directed through the heater passages by a blower or the like, heat output from the heater is high and excellent heating efficiency is obtained while the heater remains below the anomaly temperature at which its resistivity sharply increases. The cooling effect of the air moving through the heater passages also tends to maintain the heater in this high efficiency heating mode below its anomaly temperature. On the other hand, if the volume of air directed through the heater passages is reduced or cut-off so that the heater temperature tends to increase to its anomaly temperature, the heater resistivity sharply increases to reduce heater current, to stabilize the heater temperature, and to prevent overheating of the heater material. When operating in this high resistivity mode, the heat output and energy consumption of the heater are sharply reduced. However, when such a multi-passaged heater of positive temperature coefficient of resistivity is considered for use in a hair dryer or the like, it is found that it is difficult to vary the air output temperature of the dryer. It had been found to be particularly difficult to vary the temperature of the stream of air provided by the dryer without also undesirably varying the volume of heated air furnished by the dryer.

It is an object of this invention to provide a novel and improved fluid heater such as a hair dryer; to provide such a hair dryer system which is easily adjusted to regulate the temperature of air or other fluid heated by the system; to provide such a dryer which is highly efficient, which has a high air heating capacity, and which is safe to operate; and to provide such a dryer which is of simple, rugged and inexpensive construction.

Briefly described, the novel and improved hair dryer of this invention comprises a housing which defines an air path through the housing between an air intake and an air outlet. A blower of other comparable means is mounted on the housing for moving a stream of air along the air path and for directing the stream of air from the dryer through the air outlet. The dryer also includes a self-regulating electrical resistance heater formed from a body of ceramic resistance material having a plurality of fluid passages extending through the body. The resistance heater is formed from a material which has a positive temperature coefficient of electrical resistivity and which is adapted to display a sharp, anomalous increase in resistivity when the heater is self-heated to a selected temperature by directing electrical current through the heater material. The heater is mounted within the noted air path for heating air which is moved through the path by the blower means. In accordance with this invention, means are provided for adjusting the heat-transfer relationship between the heater body and the stream of air moving through the noted air path, thereby to vary the degree of heat-transfer between the body and the air to regulate the temperature of the air furnished by the dryer.

In one preferred construction, the heater body has a disc configuration and has its fluid passages extending in side-by-side relation between the broad flat surfaces of the heater disc. In this construction, the adjusting means preferably comprises means mounting the heater body for rotational movement between a first position having the heater passages extending parallel to the longitudinal axis of the air path so that substantially all air moving along the path is directed through the heater passages and a second position having the heater passages disposed oblique or perpendicular to the air path axis so that a substantial part of the air moving in the path passes around the heater without passing through the heater body passages. Air heated by being passed through the heater passages is then commingled with air passed around the heater to determine the temperature of the air stream furnished by the dryer. In this arrangement, when the heater body is moved from its first position toward its second position, the temperature of the air directed from the air outlet of the dryer is adjusted from an initial high air temperature to a relatively much lower air temperature.

In another preferred construction, the heater body has a disc-like ring configuration having a central opening of substantial size and having the heater body passages extending between opposite broad, flat disc surfaces of the heater ring. In this construction, the adjusting means preferably comprises a baffle disc rotatably mounted within the opening in the heater ring for movement between a first position perpendicular to the axis of the air path where the baffle blocks the central opening in the heater ring and directs substantially all of the air moving in the path through the heater passages and a second position extending parallel to the path axis where the baffle permits a substantial portion of the air moving in the air path to pass through the central opening in the heater ring without passing through the other passages of the heater body. In this arrangement, when the baffle is moved from its first position toward its second position, the temperature of the air directed from the dryer outlet is also adjusted from a high initial air temperature to a relatively much lower air temperature.

Other objects, advantages and details of the novel and improved fluid heater of this invention appear in the following detailed description of preferred embodiments of the invention, the detailed description referring to the drawings in which:

FIG. 1 is a side elevation view of the hair dryer provided by this invention;

FIG. 2 is a view similar to FIG. 1 partly cut away to illustrate the heater of the dryer in a first operating position;

FIG. 3 is a section view along line 3—3 of FIG. 2;

FIG. 4 is a partial view similar to FIG. 2 illustrating the heater in a second operating position;

FIGS. 5A and 5B are graphs illustrating operating characteristics of the heater of FIGS. 1-4; and

FIGS. 6, 7 and 8 are views similar to FIGS. 2 and 4 illustrating alternate embodiments of the hair dryer of this invention.

Referring to the drawing, 10 in FIGS. 1-4 indicates a preferred embodiment of the novel and improved hair dryer of this invention which is shown to include a housing 12 having an air blower 14 mounted at one end of the housing, the housing defining an air path 16 extending through the dryer between an air intake opening 18 at one end of the dryer and an air outlet opening 20 at the opposite end of the dryer. The housing 12 is preferably formed of a heat-resistant, thermosetting or thermoplastic plastic material or the like and preferably encloses an electrically operable air blower 14 of the type conventionally used in hair dryers. As the air blower 14 is conventional, it is not further described herein and it will be understood that the blower includes electrical circuit means diagrammatically illustrated by the leads 22 and 24 in FIG. 2 for electrically connecting an electrical motor in the blower to a suitable power source such as a home wall receptacle for selectively energizing the blower on closing of the switch 26 to draw air in through the intake opening 18, to move a stream of air through the air path 16, and to direct the stream of air from the outlet opening 20 of the dryer onto the hair as is diagrammatically indicated by the arrow 28 in FIGS. 1 and 2. If desired, the air blower is adapted by the use of any conventional means, as is diagrammatically indicated by the control knob 30, to selectively vary the volume or flow rate of the stream of air which is directed along the air path 16 to be directed onto the hair.

In accordance with this invention, a self-regulating electrical resistance heater 32 is formed from a body of electrical resistance material having a multiplicity of fluid passages 34 extending through the body as shown in FIG. 3, the heater material having a positive temperature coefficient of resistivity and being adapted to display a sharp, anomalous increase in resistivity when the heater material is heated to a selected anomaly temperature by directing electrical current through the heater body. The heater body is mounted within the air path 16 to be in heat-transfer relationship to a stream of air moving through the air path; means are provided for directing electrical current through the heater body; and means are provided for adjusting the heat-transfer relationship between the heater body and a stream of air moving along the air path 16.

Preferably, the heater body 32 is formed from a semiconducting ceramic material such as a lanthanum-doped barium titanate material or the like, the body preferably having a disc-like configuration as illustrated in FIGS. 2 and 3 and having a multiplicity of passages 34 extending in side-by-side relation to each other through the body between opposite broad flat disc surfaces 32.1 of the body. Typically, for example, the heater body is formed from a lanthanum doped barium lead titanate ceramic resistance material having an empirical formula of $Ba_{0.837}Pb_{0.160}La_{0.003}TiO_3$ and having a room temperature resistivity of 100 ohm-centimeters, such a material having a positive temperature coefficient of resistivity and being adapted to display a sharply increased resistivity on the order of 10,000 ohm-centimeters when heated to about 220° C. through its nominal anomaly or Curie temperature of about 200° C. Typically, the heater body 32 has a diameter of about 1.5 inches and has a thickness of about 0.350 inches and each of the passages 34 is of square cross-section of 0.050 inches per side, the passages being separated from each other by walls of equal thickness of about 0.012 inches. Preferably also, a layer of metal 36 is secured to each of the opposite sides of the heater body 32 by dip or spray coating with molten metal or in other conventional manner to serve as electrical contacts for the resistor material of the heater body while leaving the ends of the passages 34 open.

Preferably also, the heater body is mounted within the air path 16 for rotational movement between a first position shown in FIGS. 2 and 3 where the heater body passages 34 extend in parallel relation to the longitudinal axis of the air path 16 and a second position shown in FIG. 4 where the heater body passages 34 are obliquely disposed, or perpendicularly disposed, relative to the axis of the air path 16. As illustrated in FIGS. 2 and 3, the heater body is preferably proportioned to extend over the full width of the air path 16 when in the noted first position, and any conventional electrical circuit means such as flexible braids or the like are electrically connected to the heater contacts 36 as is diagrammatically illustrated by the leads 38 and 40 in FIG. 2 for electrically connecting the heater body 32 to a suitable power source for energizing the heater 32 on closing of the switch 26 while permitting rotational movement of the heater body in the air path. Typically, also, straps 42 are soldered or otherwise secured to the heater body and are provided with shaft portions 44 rotatably mounted in bushings 46 in the frame 12 (see FIG. 1) for rotatably mounting the heater in the air path 16. A handle 48 secured to one shaft 44 is then frictionally engaged as at 50 with a boss 52, the boss being formed on housing and provided with spaced grooves 54 for permitting movement of the handle to move the heater to any selected rotational position within the air path 16.

In operation of the dryer 10 as above-described, closing of the switch 26 is effective to energize the blower 14 so that ambient air is drawn in through the intake 18 and so that a stream of air at room temperature is directed toward the heater 32 as indicated by arrows 56 in FIG. 2. The switch closing also energizes the heater. When the heater is disposed in the position shown in FIG. 2, substantially all of this stream of room temperature air is directed through the heater passages 34 in excellent heat-transfer relationship to the heater body so that heat is rapidly withdrawn from the heater by the air, the heated air then being directed from the dryer outlet as indicated by the arrows 58 in FIG. 2. In this arrangement, the heater functions in a highly efficient manner to heat a stream of air having a substantial volume flow rate and, in accordance with this invention, the blower 14 is preferably adapted to provide a stream

of air at a sufficient volume flow rate, typically about 30 cubic feet per minute, so that the heater temperature tends to increase to only a limited extent, whereby the resistivity of the heater body remains relatively low as indicated at point A in FIG. 5A while the power utilization of the heater and the heat transfer to the air is high as indicated at point B in FIG. 5B. Typically, the heater is adapted to heat a stream of air having the typical flow rate noted above to a relatively high air temperature on the order of 65° C. when the heater is in the position shown in FIG. 2, the heater utilizing about 450 watts of power at this temperature.

Alternately, when the handle 48 is moved to rotate the heater 32 to the position shown in FIG. 4, only part of the stream of room temperature air is directed through the heater passages in highly efficient heat-transfer relation to the heater body as indicated by the arrow 56*a* in FIG. 4 whereas a substantial proportion of the stream of room temperature air is permitted to pass around the heater in relatively poorer heat-transfer relation, or out of effective heat-transfer relation, to the heater body as indicated by arrows 56*b* in FIG. 4. As will be understood, the heated and relatively unheated portions of the stream of air indicated by the arrows 56*a* and 56*b* are then commingled downstream in the air path 16 as indicated by the arrows 58*a* in FIG. 4 and accordingly the air directed from the dryer outlet has a relatively lower effective air temperature. In this way, movement of the handle 48 to rotate the heater between the positions shown, or to any location between these positions, is effective to adjustably vary the air output temperature of the dryer in a desirable manner. It will also be noted that this air output temperature adjustment is adapted to be accomplished without substantial change in the volume of air directed from the dryer outlet. Accordingly, the dryer 10 as above-described is adapted to accomplish major objectives of this invention.

In this regard, it will be understood that, where the portion 56*a* of the stream of air passed in highly efficient heat-transfer relation to the heater body through the heater passages is reduced, the heater temperature tends to increase and to stabilize at a somewhat higher temperature, thereby causing an increase in heater resistivity, a reduction in heater current, and a reduction in power utilization and heat output by the heater. Further, where the portion of the stream of air passed in efficient heat-transfer relation to the heater is sufficiently small so that the heater temperature increases to its anomaly temperature, the heater resistivity sharply increases as shown at point C in FIG. 5A, the heater temperature stabilizes at a selected maximum temperature, and heat output and power consumption by the heater is sharply reduced as indicated at point D in FIG. 5B. Thus, the dryer is adapted to provide a relatively very low air output temperature where desired and, even if the air intake to the dryer should be inadvertently blocked, there is no risk that the heater will be subjected to excessive overheating.

Another alternate embodiment of this invention is illustrated in FIG. 6. In this regard, it has been noted above that where the heater 32 described with reference to FIGS. 1-5 is moved between the position shown in FIGS. 2 and 4, the temperature of the air output from the dryer 10 is adapted to be varied without substantial variation to the volume flow rate of output air provided by the dryer. This maintenance of a more of less constant flow rate is dependent on the relative size of heater, the heater passages, and the air path 16. However, where the total cross-sectional area of the heater body passages 34 is substantially smaller than the cross-sectional area of the air path 16 and where the heater body thickness is also relatively small, movement of the heater 32 to the position shown in FIG. 4 may result in less restriction to air flow in the air path 16 so that some variation in the volume of air output from the dryer may occur. Accordingly, in the embodiment 10*a* of this invention illustrated in FIG. 6, wherein components of the dryer 10*a* corresponding to those illustrated in FIGS. 1-5 are identified by the same reference numerals, baffle means 60 are mounted on the heater 32, the baffle means being proportioned relative to the cross-sectional areas of the body passages 34 and the air path 16 so that air flow past the heater location is maintained substantially constant during rotation of the heater to adjust air output temperature. Preferably for example, the baffle means 60 comprises a generally cylindrical thermoplastic tube having obliquely cut ends fitted over the heater 32. In this arrangement, the baffle 60 has little effect on air flow in the path 16 when the heater passages 34 are parallel to the air path axis but, as the heater is rotated tending to reduce the restriction of air flow in the passage by permitting air to flow around the heater as indicated by the arrows 56*a* and 56*b* in FIG. 6, the baffle is moved with the heater to progressively restrict air flow and to counteract the reduction in air flow restriction caused by heater rotation. In this way air flow furnished by the dryer 10*e* is maintained at a constant level while the air temperature of the dryer output is varied by the heater rotation.

In another preferred embodiment of the hair dryer of this invention illustrated at 10*b* in FIGS. 7 and 8, the heater 32 previously described is replaced by a ring-shaped disc-like heater body 62 having a multiplicity of fluid passages 64 extending in side-by-side relation to each other between opposite broad disc surfaces 62.1 of the heater ring and having a relatively large central opening 66 formed in the ring. In this embodiment of the invention, the heater 62 is provided with metal contact layers 68 secured on opposite sides of the heater ring while leaving the passages 64 and the opening 66 fully open and is fixedly mounted within the air path 16 of the dryer with the heater passages 64 and opening 66 aligned parallel to the path axis. In accordance with this invention, a disc-like baffle 70 is mounted within the heater opening 66 in any conventional manner for permitting rotation of the baffle between a first position shown in FIG. 7 where the baffle extends perpendicular to the air path axis and effectively blocks the central opening in the heater and a second position illustrated in FIG. 8 where baffle extends parallel to the air path axis for substantially freeing the heater opening for the passage of air therethrough. In this arrangement, the blower of the heater 10*b* directs a stream of room temperature air toward the heater 62 so that, when the baffle 70 is in the position shown in FIG. 7, substantially all of this stream of heated air is directed through the heater body passages 64 as indicated by the arrows 56*c* in FIG. 7 in highly efficient heat-transfer relation to the heater body. In this way the stream of air passed through the heater passages 64 as indicated by the arrows 58*c* in FIG. 7 is heated to a relatively high temperature. However, when the baffle 70 is rotated to the position shown in FIG. 8, part of the stream of room temperature air indicated by the arrows 56*d* in FIG. 8 is permitted to pass through the heater opening 66 in rela-

tively poorer heat-transfer relation, or out of effective heat-transfer relation, to the heater body, and only a part of the stream of air is passed through the heater body passages 64. The heater portions of the stream of air passed through the passages 64 and the relatively unheated portion of the stream of air passed through the opening 66 are then commingled downstream from the heater as illustrated by the arrows 58*d* in FIG. 8, thereby to provide the output air furnished by the dryer 10*c* with a relatively lower temperature. As will be understood, the baffle 70 is easily mounted for rotation within the opening 66 by providing the baffle with a supporting shaft 72 and by mounting the shaft in bushings 74 inside the heater body, one end (not shown) of the shaft extending through the heater and out of the dryer housing to permit rotation of the baffle from outside the housing.

It will be understood that, in the preferred embodiments of this invention as described above, the blower 14 is described as moving a stream of air along the air path 16 at a selected volume flow rate while the heat-transfer relationship between the stream of air and the noted heater is moved for varying air output temperature. However, such dryers are also adapted to be provided with blowers having variable capacities as previously described for permitting variation in the flow rate of the air output from the dryer where desired. Thus, as described with reference to FIGS. 1–5, the blower output can be varied by movement of the control knob 30 after operation of the dryer has been initiated to provide the desired air flow rate through the dryer. The heat-transfer relationship between the heater and the desired stream of air is then varied in the manner above described to provide the desired air temperature. In this way, the dryer of this invention permits variation of an output temperature with or without variation of air output volume as may be desired.

It should be understood that although preferred embodiments of the hair dryer have been described by way of illustrating this invention, the invention includes various modifications and equivalents of the described embodiments falling within the scope of the appended claims.

I claim:

1. A hair dryer comprising housing means defining an air path having an inlet portion and having an outlet portion shaped to commingle air directed along the path, means moving a stream of air along said path to be directed from said dryer through the outlet portion of the path, a heater body of electrical resistance material

of positive temperature coefficient of resistivity adapted to be self-heated when electrical current is directed through the body and to display a sharp increase in electrical resistivity when heated to a selected temperature for limiting said self-heating, said body having a plurality of air flow passages extending through the body, means for directing electrical current through the body, and means mounting the body for movement between a first position in the path permitting a selected proportion of the stream of air moving in the path to pass in heat-transfer relation to the body through said body passages to withdraw heat from the body for heating said air and for tending to maintain the resistivity of the body material at a relatively low level to enhance heat output by the body and a second position permitting a relatively lesser proportion of the stream of air moving in the path to pass in heat-transfer relation to the body through the body passages and to commingle in the outlet portion of the path with other air moving along the path outside the body passages for regulating the temperature to which the air is heated while moving along the path and while assuring that any resulting reduction in heat-withdrawal from the body results in increased resistivity of the body material for avoiding overheating of the body, said housing means defining said air path with a portion thereof of selected cross-sectional area and said heater body having a disc-shape with broad opposite side surfaces and having said body passages extending through the body between said opposite surfaces, said body being mounted in said air path portion for movement between said first position wherein said broad surfaces extend normal to the longitudinal axis of the path so that substantially all of the stream of air moving in the air path portion passes in heat-transfer relation to the body through the body passages and said second position wherein said body surfaces extend obliquely relative to the longitudinal axis of the path permitting a relatively less proportion of the stream of air moving in the air path portion to pass in heat-transfer relation to the body through the body passages and permitting other air moving in the air path portion to pass around the heater body and to commingle with the air passed through the body passages.

2. A hair dryer as set forth in claim 1 having a baffle means mounted for movement with said heater body to maintain air flow restriction in said path at a substantially constant level during said movement of said heater body.

* * * * *

United States Patent [19]
Hasegawa

[11] **Patent Number:** 5,077,461
[45] **Date of Patent:** Dec. 31, 1991

[54] **FAR-INFRA-RED HEATER**

[75] Inventor: **Nobuyuki Hasegawa**, Miyagi, Japan

[73] Assignee: **Tokai Konetsu Kogyo Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **433,739**

[22] Filed: **Nov. 9, 1989**

[30] **Foreign Application Priority Data**

Jun. 9, 1987 [JP] Japan 62-143509

[51] **Int. Cl.**[5] **H05B 3/10**

[52] **U.S. Cl.** **219/553**; 219/464; 219/544; 428/372; 428/447

[58] **Field of Search** 219/553, 464, 544, 411, 219/552; 428/447, 450, 446, 372; 392/407

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,612,828	10/1971	Siegla	219/464
4,824,730	4/1989	Fukuda et al.	219/553
4,917,739	4/1990	Adam et al.	148/437
4,965,434	10/1990	Nomura et al.	392/407
4,999,243	3/1991	Maeda	428/372

OTHER PUBLICATIONS

Technical Bulletin GR-1 by the Carborundum Company, Globar; *Types A, B, and CX Resistors*, 1958.
Technology Concise brochure by Management Systems Institute, pp. 207-231.

Primary Examiner—Bruce A. Reynolds
Assistant Examiner—Tu Hoang
Attorney, Agent, or Firm—Seed and Berry

[57] **ABSTRACT**

A far infra-red heater comprises a resistance heating element composed of an insulating and heat resistance structural material and 5 to 60% by weight of Si or FeSi as a conductive material dispersed in the structural material. In the far infra-red radiating heater, a ceramic resistance heating element per se efficiently radiates light having a wave length falling within the far infra-red region, the heater has high thermal efficiency and sufficient mechanical strength and can be used at a temperature of up to about 600° C.

20 Claims, 1 Drawing Sheet

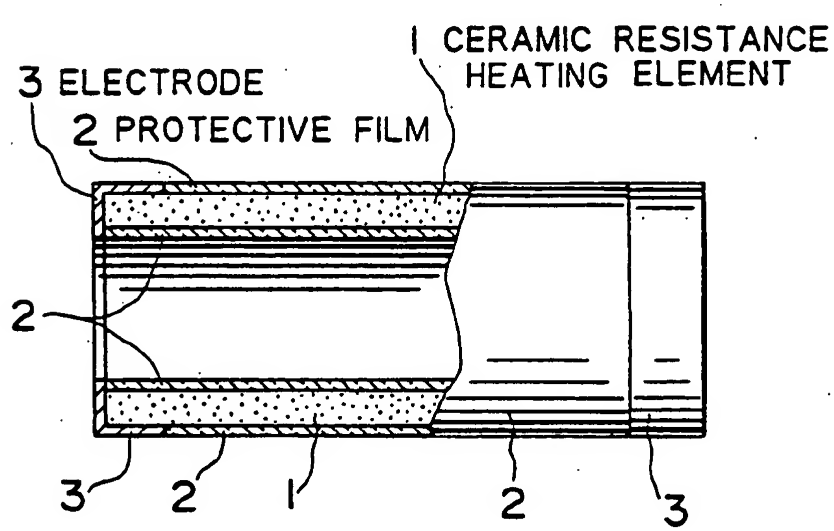


FIG. 1

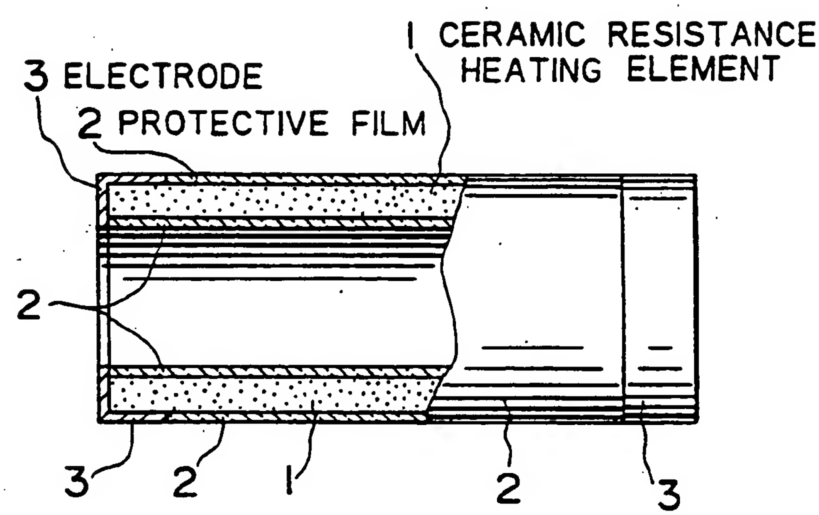
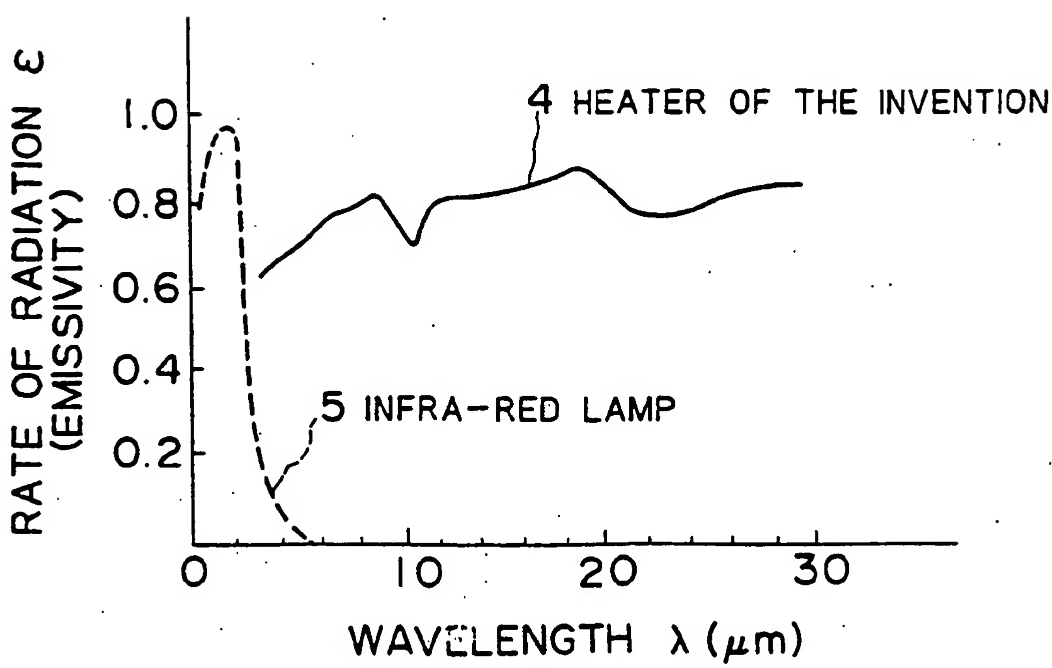

1 CERAMIC RESISTANCE HEATING ELEMENT
3 ELECTRODE
2 PROTECTIVE FILM
2
3
2
1
2
3

FIG. 2


RATE OF RADIATION ε (EMISSIVITY)
1.0
0.8
0.6
0.4
0.2
4 HEATER OF THE INVENTION
5 INFRA-RED LAMP
0
10
20
30
WAVELENGTH λ (μm)

FAR-INFRA-RED HEATER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a far infra-red heater. More specifically, the present invention pertains to a far infra-red heater which comprises a ceramic resistance heating element obtained by mixing and dispersing an insulating heat resistant component and a conductive component, wherein the resistance heating element per se directly radiates rays having a wave length falling within the far infra-red region efficiently.

2. Description of the Prior Art

Up to now, there have been knwon various far infra-red heaters such as (1) an infra-red heater comprising a quartz tube and a tungsten filament enclosed therein or a quartz tube heater comprising a quartz pipe and a nichrome wire enclosed therein; (2) a heater obtained by coating the metal surface of a sheathed wire heater, which comprises a metal tube and a nichrome wire enclosed therein through an insulater such as magnesium oxide, with a ceramic far infra-red radiating material such as those comprising alumina, zirconia and titania; and (3) a heater comprising a ceramic tube made of the foregoing far infra-red radiating material and a nichrome wire enclosed therein.

In the aforementioned far infra-red heaters, a commercial voltage is in general applied to both ends thereof to generate Joule heat whereby the temperature of the surface of the heater is raised to a predetermined level ranging from 200° to 600° C. If the temperature of the heater is raised, the radiant quantities of infra-red rays correspondingly increase, thus a substance to be heated is irradiated with the infra-red rays radiated by the heater and the surface of the substance absorbs the infra-red rays whereby the substances per se are heated.

For this reason, the heating effect of the far infra-red rays greatly depends on the radiation properties of a far infra-red heater and the infra-red absorption characteristics of a substance to be heated.

In other words, a far infra-red heater should radiate infra-red rays compatible with the absorption characteristics of a substance to be heated. Under such circumstances, various kinds of heaters have practically been used depending on a variety of applications. Examples of typical applications of such heaters are baking and drying of paints, inks or the like, drying of lumbers, grilling of foods and heating such as floor heating and a sauna.

The foregoing conventional far infra-red heaters suffer from the following disadvantages:

First of all, in the aforementioned infra-red lamp or the quartz tube heater (1), light generated by an electrically heated wire is radiated through quartz wall. As a result, the wave length of the principal radiant rays falls within the range of near infra-red rays in the order of 1.5μ and, therefore, such a heater or a lamp does not radiate sufficient quantity of light having a wave length falling within the far infra-red range. Moreover, these heaters have low mechanical strength.

Although the aforesaid heaters (2) obtained by coating a sheathed wire heater with a ceramic far infra-red radiating material efficiently radiate far infra-red rays having a wave length of 3 to 50μ, they suffer from an inevitable problem that the ceramic radiating material is peeled off from the surface of the metal tube due to the difference between the thermal expansion coefficients of the metal tube and the ceramic radiating material applied onto the surface of the former.

The foregoing heaters (3) comprising a ceramic tube and a nichrome wire enclosed therein make it possible to solve the problem of peeling off of the coated material associated with the foregoing sheathed wire heaters (2), they can be made lighter since it is not necessary to use any insulating materials and they make it possible to improve their thermal efficiency. However, they still suffer from drawbacks originated from the fact that the heating is performed by an indirect heating method in which a radiant is indirectly heated by heating a nichrome wire. More specifically, a problem that the electrically heated wire such as a nichrome wire is locally heated abnormally to thus result in burning out of the wire due to the increase in the resistance of the wire because of its oxidation and corrosion has not yet been solved. Moreover, they further suffer from the problems concerning, for instance, thermal energy loss due to indirect heating; uneven distribution of temperature and retardation of response time in the temperature control.

SUMMARY OF THE INVENTION

The present invention intends to solve these problems and a principal object of the present invention is to provide a far infra-red radiating heater in which a ceramic resistance heating element per se efficiently radiates light having a wave length falling within the far infra-red region, which has high thermal efficiency and sufficient mechanical strength and which can be used at a temperature of up to about 600° C.

The foregoing object of the present invention can effectively be attained by providing a far infra-red heater which comprises a resistance heating element composed of an insulating and heat resistant structural material and 5 to 60% by weight of Si or FeSi as a conductive material dispersed in the structural material.

BRIEF DESCRIPTION OF THE DRAWINGS

The far infra-red heater of the present invention will be described in more detail with reference to the accompanying drawings, wherein

FIG. 1 is a sectional view of the principal parts of an embodiment of the far infra-red heater according to the present invention; and

FIG. 2 is a graph showing the relation between the wave length of the heater of this invention and that of a conventional infra-red lamp and their spectral rate of radiation (emissivity).

DETAILED EXPLANATION OF THE INVENTION

Examples of the most preferred insulating heat resistant structural materials as used herein include ceramic materials principally comprising aluminosilicates. This is because these ceramic materials have high rate of radiation and can be sintered at a temperature less than the melting point of Si (1410° C.). As other heat resistant structural materials which may be used in the present invention, there may be mentioned, for instance, those listed below (in the following composition, "%" means "% by weight"):

(i) ZrO_2. TiO_2 type: ZrO_2. SiO_2 40~60%, TiO_2 5~25% ZrO_2. SiO_2 30~50%, TiO_2 25~60%

(ii) Al_2O_3. TiO_2 type: Al_2O_3 40~70%, TiO_2+SiO_2 25~45%

(iii) TiO_2 type: TiO_2 not less than 90%; Cr_2O_3 not more than 10%

(iv) Fe_2O_3. SiO_2 type:
Fe_2O_3 25~45%,
SiO_2 25~45% (slug of copper minerals)
SiO_2 30~80%,
$Al_2O_3+Fe_2O_3$ 5.5~60%

(v) Those which comprise a mixture of at least one member selected from the group consisting of oxides, carbides and nitrides of elements of Group II and III of the Periodic Table with at least one member selected from the group consisting of oxides, carbides and nitrides of elements of Group IV and V of the Periodic Table, for instance, MgO-Fe_2O_3-SiO_2-TiO_2-CaO-MnO_2-ZrO_2 type ones.

(vi) SiC type ones.

The structural materials principally comprising aluminosilicate generally contain 0.5 to 30% of a metal oxide (comprising at least one member selected from the group consisting of Fe_2O_3, Cr_2O_3, Mn_2O_3, ZrO_2, TiO_2, MnO_2, Li_2O, CaO, MgO, NiO, CoO and Cu_2O) in addition to Al_2O_3 and SiO_2. Specific examples of such structural materials are as follows:

	SiO_2 (%)	Al_2O_3 (%)	K_2O (%)
KIBUSHI clay	49	33	
GAIROME clay	47	35	
Kaolin	45	40	
AMAKUSA pottery stone	47	36	
Potash feld spar	65	20	11
Pyroferrite	66	27	
Bentonite	59	14	

In addition to the foregoing examples, petalite (Li_2O, Na_2O, Al_2O_3, $8SiO_2$) and talc ($4SiO_2$, $3MgO$, H_2O) can also be used in the invention.

In the far infra-red heaters of this invention, the foregoing structural material such as the aforesaid clayey materials may be used alone or in combination. More preferably, these structural materials in which glass components are incorporated are used.

The glass components are not restricted to specific ones so far as they are heat resistant at a temperature at which the resultant heater is employed, but silicate glasses having a low thermal expansion coefficient such as SiO_2 type glasses, SiO_2-Al_2O_3 type glasses, SiO_2-B_2O_3 type glasses, SiO_2-Li_2O type glasses and SiO_2-ZnO type glasses are particularly preferred in the present invention to improve the thermal shock resistance of the resulting resistance heating element. Moreover, the glass component may be crystalline glasses which are converted into a ceramic after calcination. Specific examples thereof will be listed below:

EXAMPLES OF NON-CRYSTALINE GLASSES

1) SiO_2 type glasses (SiO_2 100% [quartz powder], SiO_2 96%);
2) B_2O_3-SiO_2 type glasses (SiO_2 80%, B_2O_3 10%, Al_2O_3 4%)
3) Al_2O_3-SiO_2 type glasses (SiO_2 55%, Al_2O_3 23%, B_2O_3 7%)

EXAMPLES OF THE CRYSTALLINE GLASSES

1) LiO_2-SiO_2 type glasses (SiO_2 65~81%; Li_2O 7~15%; Al_2O_3 4~20%)
2) ZnO-SiO_2 type glasses (SiO_2 44~51%; ZnO 19~26%; Al_2O_3 17~23%)

3) MgO-Al_2O_3-SiO_2 type glasses (SiO_2 43~64%; MgO 13~25%; Al_2O_3 14~31%)
4) Li_2O-Al_2O_3-SiO_2 type glasses (SiO_2 59~70%; Li_2O 3~4%; Al_2O_3 12~15%)

The amount of the glass component to be incorporated into the structural materials preferably ranges from 10 to 50% by weight on the basis of the total weight of the structural material.

Specific formulations of the structural materials of the present invention are as follows:

1) KIBUSHI clay 70%; borosilicate glass 30%
2) GAIROME clay 70%; feldspar 30%
3) alumina 30%; KIBUSHI clay 30%; aluminosilicate glass 40%
4) kaolin 60%; KIBUSHI clay 15%; talc 15%; magnesite 10%
5) petalite 75%; lithium carbonate 15%; alumina 10%

The resistance heating element of the present invention can be prepared by adding a conductive material, i.e., Si or FeSi, water and optionally a proper binder to a structural material, for instance, a clayey component or a combination of a clayey component and a glass component, kneading the mixture, forming the mixture into a desired shape and then calcining the same at a temperature ranging from 1,000° to 1,400° C.

The conductive material, i.e., Si or FeSi is added to the structural material for the resistance heating element in an amount ranging from 5 to 60% by weight on the basis of the total weight of the resistance heating element. The resistance of the resistance heating element can be freely adjusted within the range of from 10^{-2} to 10^{1} Ω·cm by changing the amount of Si or FeSi to be incorporated into the structural material. In addition, the resistance heating element of the present invention has a positive resistance thermal coefficient. If the amount of Si or FeSi is less than 5% by weight, the resistance of the resultant resistance heating element is too large to ensure the functions of the resultant product as a resistance heating element, while if it is more than 60% by weight, the resistance of the resultant resistance heating element becomes too low and it also has low mechanical strength.

When the structural material contains a glass component and the structural material is calcined at a temperature ranging from 1,000 ° to 1,400° C., molten glass component flows out on the surface of the structural material to thus form an insulating glass protective film or layer on the surface of the resistance heating element. On the other hand, if the structural material does not contain a glass component and the material is calcined at a temperature ranging from 1,000° to 1,400° C. in the air, silicon present on the surface thereof is oxidized to thus form an insulating SiO_2 protective film or layer on the surface of the resulting resistance heating element. Alternatively, it is also possible to calcine the structural material in an inert gas atmosphere such as argon gas atmosphere and then it is again calcined in an oxidizing gas atmosphere such as air to thus form a protective film or layer on the surface of the resultant resistance heating element.

The raw material for the resistance heating element can be formed into a desired shape by any known methods such as extrusion molding, pressure molding in a mold and doctor blade molding. The resistance heating element of the present invention may be formed into

any shapes such as tubular, rod-like and plate-like shapes. A conductive film is formed on the both ends of the resistance heating element by a metal spray technique, welding technique or baking of a conductive paste to obtain a far infra-red heater.

The far infra-red heater of the present invention thus manufactured can efficiently radiates far infra-red rays having a wave length ranging from 3 to 50μ and can stably be used at a temperature of up to 600° C.

The frequency of the far infra-red rays coincides with the intrinsic molecular frequency of polymeric compounds and, therefore, heaters should radiate a large quantity of energy falling within the far infra-red region. The heaters of the present invention can radiate a large quantity of energy within the range of far infra-red rays and are applicable in most of applications in which far infra-red rays are employed for heating.

Moreover, the electrical conditions and the temperature conditions of the resulting heater may be freely selected by changing the amount of Si or FeSi to be incorporated as has been described above. In general, the heaters are frequently used so that the surface temperature of 400° C. is established when the commercial voltage is applied thereto.

As has been described above, the purpose of the present invention is to improve the temperature distribution and the responsibility (response time) of the heater. The former is greatly improved since the heaters of this invention have a uniform composition, while regarding the latter, there can be provided heaters exhibiting fast responsibility compared with the conventional heaters since the material for the heater is identical with the far infra-red radiating material.

As has been described above, the heaters of the present invention simultaneously have a variety of properties required for far infra-red heating and are hence practically applicable in most of applications. Therefore, the heaters of the present invention are epoch-making ones.

The present invention will hereunder be described in more detail with reference to the following non-limitative working Examples and the effect practically attained by the invention will also be discussed in detail.

EXAMPLE

FIG. 1 is a sectional view of the principal parts of an embodiment of the far infra-red heater according to the present invention.

A resistance heating element 1 coated with an insulating glass protective film 2 having an outer diameter of 15 mm, an inner diameter of 10 mm and a length of 500 mm was manufactured by hydrating and mixing a mixture of 65% by weight of a starting material composed of 70% by weight of KIBUSHI clay and 30% by weight of borosilicate glass having a thermal expansion coefficient of not more than $50\times10^{-7}/°$ C. and a softening point of not less than 700° C. and 35% by weight of silicon powder; forming the mixture into a tube-like product; drying the shaped product; and then calcining the shaped product at a temperature ranging from 1,300° to 1,400° C. in the air. The glass protective film 2 n the both ends of the resultant heating element 1 was removed over a width of 15 mm and then the ends thereof was subjected to metal spray of Al to form electrodes 3.

The spectral rate of radiation at each wave length at the surface temperature of 500° C. was determined on the far infra-red heater of the present invention thus manufactured and the results obtained were plotted on FIG. 2. As seen from the data plotted on FIG. 2, it is confirmed that the heater of the invention effectively radiates far infra-red rays having a wave length ranging from 3 to 30μ as compared with the conventional infra-red lamp (see the broken line on FIG. 2). In addition, the heater of the invention has the following excellent physical properties: porosity=0%; thermal expansion coefficient=$40\times10^{-7}/°$ C. (at a temperature between 0° to 600° C.); bending strength as determined according to JIS-R-1601=700 to 1,000 kg/cm^2. These physical properties indicate that the heater of the invention is composed of a compact material having a low thermal expansion coefficient and that it has high bending strength. Therefore, it is clear that the heater has sufficient resistance to thermal shock and practically acceptable mechanical strength.

When a voltage of 100 V was applied to the foregoing far infra-red heater of the invention, the power thereof was 400 W and the surface temperature was 400° C. Regarding the responsibility, when the heater was used as a heat source for a hair dryer, the temperature of the heater reached 350° C. after 60 seconds, while the temperature of a conventional heater comprising a ceramic tube and a nichrome wire enclosed therein was raised to only 150° C. after 60 seconds. Moreover, the heater of the present invention exhibits very good temperature distribution. More specifically, that of the conventional heater was ±12° C., while that of the heater of the invention was ±6° C. When the hair dryer was used for having the hair permed, such an operation could be performed for a very short period of time and the finished condition of the hair was uniform and excellent.

As has been practically demonstrated in the foregoing Example, the far infra-red heater of the present invention shows the following effects since the ceramic resistance heating element per se serves as the far infra-red radiant:

(1) It can be formed into any shape and the far infra-red radiant per se can directly generate heat. Therefore, it has a low heat capacity, quick heating properties and a high thermal efficiency. Moreover, the temperature control of the heating element can be rapidly performed. Thus, it shows a high energy-saving effect.

(2) It has a high mechanical strength and hence the use of any reinforcing materials is not needed. Moreover, the resistance of the heater may be freely selected within a certain range by adjusting the amount of the conductive material such as Si or FeSi to be incorporated thereinto. Therefore, there is very large room for the design of the far infra-red heater.

(3) It is not necessary to use a nichrome wire in the ceramic heating element of the invention. Therefore, there is no possibility of burning out and good temperature distribution can be attained.

(4) The method for manufacturing the heaters and the structure thereof are quite simple. Thus, the heater of this invention can be supplied at a low price.

What is claimed is:

1. A far infra-red heater comprising a resistance heating element composed of an insulating and heat resistant structural material and 5 to 60% by weight of Si or FeSi as a conductive material dispersed in the structural material.

2. The far infra-red heater of claim 1 wherein it further comprises an insulating glass protective layer on the resistance heating element.

3. The far infra-red heater of claim 1 wherein the insulating and heat resistant structural material is a material principally comprising an aluminosilicate.

4. The far infra-red heater of claim 1 wherein the insulating and heat resistant structural material is selected from those capable of being sintered at a temperature less than 1410° C.

5. The far infra-red heater of claim 4 wherein the insulating and heat resistant structural material is selected from the group consisting of (i) $ZrO_2 . TiO_2$ type glasses; (ii) $Al_2O_3 . TiO_2$ type glasses; (iii) TiO_2 type glasses containing not less than 90% of TiO_2 and not more than 10% of Cr_2O_3; (iv) $Fe_2O_3 . SiO_2$ type glasses; (v) a mixture of at least one member selected from the group consisting of oxides, carbides and nitrides of elements of Group II and III of the Periodic Table with at least one member selected from the group consisting of oxides, carbides and nitrides of elements of Group IV and V of the Periodic Table; and (vi) SiC type ones.

6. The far infra-red heater of claim 1 wherein the insulating and heat resistant structural materials principally comprising aluminosilicate contains 0.5 to 30% of at least one metal oxide selected from the group consisting of Fe_2O_3, Cr_2O_3, Mn_2O_3, ZrO_2, TiO_2, MnO_2, Li_2O, Cao, MgO, NiO, CoO and Cu_2O in addition to Al_2O_3 and SiO_2.

7. The far infra-red heater of claim 1 wherein the insulating and heat resistant structural material is a member selected from the group consisting of KIBUSHI clay, GAIROME clay, kaolin, AMAKUSA pottery stone, potash feld spar, pyroferrite, bentonite, petalite and talc.

8. The far infra-red heater of claim 1 wherein the insulating and heat resistant structural material further comprises glass components.

9. The far infra-red heater of claim 8 wherein the glass components is selected from the group consisting of SiO_2 type glasses, SiO_2-Al_2O_3 type glasses, SiO_2-B_2O_3 type glasses, SiO_2-Li_2O type glasses, SiO_2-ZnO type glasses and crystalline glasses which are converted into a ceramic after calcination.

10. The far infra-red heater of claim 8 wherein the glass component is selected from the group consisting of 1) SiO_2 type glasses; 2) SiO_2-B_2O_3 type glasses; 3) SiO_2-Al_2O_3 type glasses.

11. The far infra-red heater of claim 8 wherein the crystalline glass is selected from the group consisting of 1) LiO_2-SiO_2 type glasses containing SiO_2 65~81%; Li_2O 7~15%; and Al_2O_3 4~20%; 2) ZnO-SiO_2 type glasses containing SiO_2 44~51%; ZnO 19~26%; and Al_2O_3 17~23%; 3) MgO-Al_2O_3-SiO_2 type glasses containing SiO_2 43~64%; MgO 13~25%; and Al_2O_3 14~31%; and 4) Li_2O-Al_2O_3-SiO_2 type glasses containing SiO_2 59~70%; Li_2O 3~4%; and Al_2O_3 12~15%.

12. The far infra-red heater of claim 8 wherein the amount of the glass component to be incorporated into the structural materials ranges from 10 to 50% by weight on the basis of the total weight of the structural material.

13. The far infra-red heater of claim 8 wherein the structural materials is selected from the group consisting of:

1) KIBUSHI clay 70% and borosilicate glass 30%;
2) GAIROME clay 70% and feld spar 30%;
3) alumina 30%, KIBUSHI clay 30% and aluminosilicate glass 40%;
4) kaolin 60%, KIBUSHI clay 15%, talc 15% and magnesite 10%; and
5) petalite 75%, lithium carbonate 15% and alumina 10%.

14. The far infra-red heater of claim 1 wherein the resistance of the resistance heating element ranges from 10^{-2} to 10^1 Ω·cm.

15. The far infra-red heater of claim 1 wherein it radiates far infra-red rays having a wave length ranging from 3 to 50 μ and is used at a temperature of up to 600° C.

16. A method for generating far infra-red rays, which comprises applying electric voltage to a heater comprising a resistance heating element composed of an insulating and heat resistant structural material and 5 to 60% by weight of Si or FeSi as a conductive material dispersed in the structural material to thereby heat the surface of the heat temperature of 200° C. to 600° C.

17. The method claim 16 wherein the heater further comprises an insulating glass protective layer on the resistance heating element.

18. The method of claim 16 wherein the insulating and heat resistant structural material is selected from the group consisting of (i) $ZrO_2 . TiO_2$ type glasses; (ii) $Al_2O_3 . TiO_2$ type glasses; (iii) TiO_2 type glasses containing not less than 90% of TiO_2 and not more than 10% of Cr_2O_3; (iv) $Fe_2O_3 . SiO_2$ type glasses; (v) a mixture of at least one member selected from the group consisting of oxides, carbides and nitrides of elements of Group II and III of the Periodic Table with at least one member selected from the group consisting of oxides, carbides and nitrides of elements of Group IV and V of the Periodic Table; and (vi) SiC type ones.

19. An apparatus for generating far infra-red rays, which comprises a resistance heating element composed of an insulating and heat resistant structural material and 5 to 60% by weight of Si or FeSi as a conductive material dispersed in the structural material and electrodes provided on the both ends of the element.

20. The apparatus of claim 19, wherein the element is in the form of a bar.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,077,461

DATED : December 31, 1991

INVENTOR(S) : Nobuyuki Hasegawa

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In column 7, claim 6, line 25, please delete "Cao" and substitute therefor -- CaO --.

Signed and Sealed this

Sixth Day of April, 1993

Attest:

STEPHEN G. KUNIN

Attesting Officer

Acting Commissioner of Patents and Trademarks